The nonlocality vs. nonrealism: the critical discussion and a new proposal.

Jiri Soucek

Charles University in Prague, Faculty of Philosophy
Ke Kříži 8, Prague 5, 158 00, Czech Republic
jiri.soucek@ff.cuni.cz

Abstract. We discuss the three options: the psi-ontic position, the psi-epistemic position and the novel psi-hybrid position.

With Bell inequalities (BI) there is a problem. They are in contradiction with Quantum Mechanics (QM) and also with the experiments. Both locality and realism must be assumed in their derivations. (Instead of the realism one can assume the so-called counterfactual definiteness.) This means that both locality and realism are necessary assumptions in the proof of BI. There are two possibilities to make BI un-derivable: either to reject the locality or to reject the realism.

The nonlocality approach was studied in hundreds (perhaps thousands) papers during last 50 years while the nonrealism approach was considered only in general terms and there is (as I know) only one concrete explicit proposal, the modified QM (see [1]).

I think that such a situation is not fair with respect to the nonrealism approach and that the nonrealism position should be considered as serious as the nonlocality position and it should be studied equally seriously.

This situation is incorrect from the point of view of the scientific methodology: the nonrealism position cannot be rejected on the scientific grounds (PBR theorem uses many unjustified assumptions, mainly the assumption of ontological models) it should be studied as well as the opposite position. (On the other hand, the nonlocality position has the serious drawback that the nonlocality contradicts the Special Relativity.)

In the taxonomy given below (see [4]) I do not consider the question of the completeness since it is irrelevant for the present purposes.

The realism position ("the wave function represents the state of the individual system") is equivalent to the von Neumann axiom ("the ensemble in a pure state is homogeneous"). It is often denoted as the psi-ontic position. This position has many serious drawbacks: it implies the Collapse rule, it creates the Measurement problem, the Schrodinger cat paradox etc. Nevertheless, it make a part of the standard QM.

The opposite position – the nonrealism position, called also as the psi-epistemic position assumes that the wave function represents the state of an ensemble (this was Einstein`s opinion). It is known also as the statistical interpretation of QM. The problem with this

position is the missing concept of an individual system and its possible individual state: there are only ensembles. Recently it is also considered as the operational approach to QM.

Quite recently there was proposed the third possibility which is intermediate between realism and nonrealism positions – it is called the psi-hybrid position. It was proposed as a bases of the modified QM in [1] and it assumes that some wave functions represent individual states of the system (psi-ontic states) while others wave functions represent states of ensembles (psi-epistemic states). Typically the set of individual states is the orthogonal base of the system`s Hilbert space. This position is psi-hybrid, i.e. ontic-epistemic.

The psi-hybrid position takes the best of both others positions:

(i) It excludes the derivation of Bell inequalities and thus does not lead to the nonlocality (see [2], meta-theorem B)
(ii) There is no Collapse problem (it is replaced by the Selection process (see [1], [3])
(iii) There is a possibility to solve the Measurement problem (see [1], [3])
(iv) It contains the concept of an individual system and its individual state (the set of individual states is the small subset of the set of pure states)
(v) It is possible to give the local explanation of the EPR correlations (see [3]) – it is shown that there is the anti-correlation between the two individual states of measurement apparatuses in the EPT experiment (without the need of the pre-determination)
(vi) The important fact is the statement that modified QM has the same experimental consequences as the standard QM (see [1], [2]). This means that the choice between the standard QM and the modified QM depends only on theoretical properties of these theories and it cannot be resolved by the experiment. This is rather strange situation but it seems to be the real fact.

Conclusions. Besides the two known options, psi-ontic and psi-epistemic options there exists a novel psi-hybrid option which exhibits quite interesting properties.

References

[1] J. Soucek, The restoration of locality: the axiomatic formulation of the modified Quantum Mechanics, viXra:1503.0109, available also at http://www.ijqf.org/wps/wp-content/uploads/2015/06/201503.pdf

[2] Jiri Soucek, The Hidden Error in the Standard Quantum Mechanics, http://vixra.org/pdf/1507.0083v1.pdf

[3] J. Soucek, The principle of anti-superposition in QM and the local solution of the Bell's inequality problem, http://www.nusl.cz/ntk/nusl-177617, available also at http://vixra.org/abs/1502.0088

[4] N. Harrigan, R. Spekkens, Einstein, incompleteness, and the epistemic view of quantum states, arXiv:0706.2661v1 (2007)